INSTRUCTION MANUAL
DALE *600 and 600E*

ELECTRICAL
SAFETY ANALYZERS

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INTRODUCTION

The **DALE** *600* and *600E* Electrical Safety Analyzers are highly versatile and portable instruments. They are used for the basic electrical safety evaluation of electrical systems, medical devices and physiological instrumentation. Their compact hand held size makes them an ideal addition to a service technician or engineer's tool box for that "after service test" as well as serving as a bench top instrument for the laboratory. They do not sacrifice functions or accuracy and their low cost permits putting one on each bench.

The analyzers are simple to use. A single master function switch directly labeled with the test to be performed leads the user through a complete measurement procedure. A single range meter for each measurement avoids potential erroneous readings.

The analyzers utilizes simple, yet sophisticated electronics for true RMS measurement of current and voltage. Input impedance uses the AAMI ES1-1993 test load to compensate for high frequency components in the measurement. Resistance measurements are made with a four wire Kelvin bridge to eliminate errors due to cable length and connector resistance.

Unique to the **DALE** *600/600E* Electrical Safety Analyzers are their capability to make a broad range of external measurement. These include leakage current and/or voltage gradients and resistance between two points. Also, the analyzers provides the voltage and measuring provision for the independent measurement of the isolation current of a device. Thus the analyzers provides the additional versatility for evaluation of the electrical system, system installation and separately, isolation of probes and transducers in addition to the conventional leakage current measurements.

KEY FEATURES:

- ☐ Hand held instrument
- ☐ Test power line integrity (**DALE** *600* only)
- ☐ Line voltage
- ☐ Instrument current
- ☐ Grounding resistance via 4 wire
- ☐ Earth current
- ☐ Enclosure (chassis) current
- ☐ Patient (lead to ground) leakage current
- ☐ Patient (lead to lead) auxiliary current
- ☐ Patient isolation (sink) current
- ☐ External voltage gradient
- ☐ Device to device resistance
- ☐ Device to device leakage current
- ☐ Probe and transducer isolation current
- ☐ True RMS measurement
- ☐ AAMI Test Load
- ☐ Test points

WARNINGS AND CAUTIONS

WARNINGS

- ☐ DISCONNECT ALL PATIENT CONNECTIONS BEFORE CONNECTING THE DEVICE TO BE TESTED TO THE ANALYZER.

  Continued connection may jeopardize patient safety by possible application of measurement currents.

- ☐ ISOLATION TEST UTILIZES 120 OR 240 VAC APPLIED TO PATIENT LEADS OR TO EXTERNAL CONNECTIONS WHICH ARE ACCESSIBLE TO THE TESTER. MAINTAIN CARE WHEN MAKING CONNECTIONS.

  Although the voltage is current limited to 1 mA per AAMI test procedure and is safe for healthy intact skin contact, it can be felt and can result in a startle reaction.

CAUTIONS

- ☐ BE SURE THAT THE DEVICE UNDER TEST POWER REQUIREMENTS ARE WITHIN THE CAPABILITIES OF THE SAFETY ANALYZERS, LABELED AS 15 AMPS AT 120 VOLTS FOR THE DALE *600* AND 10 AMPS AT 240 VOLTS FOR THE 600*E*.

  While the analyzers are equipped with receptacle limiting access to devices of higher ratings, replacement cord set may have been installed incorrectly.

- ☐ THE DALE *600* AND *600E* ARE NOT DESIGNED FOR CONTINUOUS MEASUREMENTS. DO NOT LEAVE THE DEVICE UNDER TEST CONNECTED AND DRAWING HIGH LOAD CURRENT FOR EXTENDED PERIODS.

  To maintain its small hand held size, the analyzer was not designed to provide it's high current capability continuously and may overheat.

- ☐ BE SURE TO PAUSE IN THE OFF (MIDDLE) POSITION WHEN SWITCHING POLARITY FROM NORMAL TO REVERSE.

  Inductive loads of the device under test may create high voltage transients when trying to reverse the direction of current flow instantaneously.

SPECIFICATIONS

LINE VOLTAGE	
Range	Line voltage
Accuracy	± 3%R, ± 1 digit
LOAD CURRENT	
Range	0 - 19.99 Amps
Accuracy	± 5%R, ± 1 digit
GROUND RESISTANCE	
Range	0 - 19.99 Ohms
Accuracy	± 1%R, ± 1 digit
Current source	10 mA DC
Type	4 wire bridge
LEAKAGE CURRENT	
Range	0 - 1999 µA
mA switch OPTION	0 - 19.99 mA
Accuracy	
DC and 25 Hz to 1 KHz	± 1 %R, ± 1 digit
1.0 KHz to 100 KHz	± 2.5 %R, ± 1 digit
100 KHz to 1 MHz	± 5 %R, ± 1 digit
Type measurement	True RMS
Impedance	1000 Ω, AAMI ESI 1993
ISOLATION TEST	
Voltage	Line voltage ± 5%
Current	limited @ 1 mA
CURRENT CAPACITY	
DALE *600*	15 Amps
DALE *600E*	10 Amps
ENVIRONMENTAL	
Operating Temperature	15-40°C
Storage Temperature	-20-65°C
Relative Humidity	90 % max
Mains voltage range	
DALE *600*	100 - 130 Volts 50/60 Hz
DALE *600E*	200 - 260 Volts 50/60 Hz

CONTROLS AND INDICATORS

Refer to Figures 1 & 2

1. **POWER CORD** supplies power to the **DALE** ***600/600E*** Electrical Safety Analyzers and to the device under test (DUT). The measurement circuits are energized when the power cord is plugged into an outlet. There is no on/off switch.

2. **OUTLET INDICATORS (DALE** ***600*** only) verify the polarity and wiring of the outlet to which the Analyzer is connected. Only correctly wired outlets should be used. Not applicable to isolated power systems.

3 **TEST RECEPTACLE** for supplying power to the device under test (DUT), **DALE** ***600***, 15 A, 125 V, NEMA 5-15R .and **DALE** ***600E*** 10 A, 230 V, NEMA 6-15R

4. **POLARITY SWITCH** with center **OFF** position permits testing with both the **NORMAL** (FORWARD) and **REVERSED** polarity of the line. It is recommended that the switch is paused in the center **OFF** position before changing polarity.

5. **NEUTRAL SWITCH** permits making leakage current measurements under the **OPEN** neutral condition as required by UL and IEC.

6. **LIFT GROUND/ISO TEST** switch is a dual function switch. The **LIFT GND** position will open ground to the device for leakage current measurements. The **ISO TEST** position will energize the selected patient lead at line voltage, current limited, to measure the isolation current when the main function switch is in the **LEAD ISOLATION** position. With the function switch in the **EXTERNAL** position, the isolation test voltage is supplied to the **EXTERNAL** connector for measuring the isolation current of a probe or transducer.

7 **FUNCTION SWITCH** provides direct one step selection of the measurement to be made. These are line **VOLTAGE**, instrument **CURRENT**, grounding **RESISTANCE**, **EARTH** (internal) and **CHASSIS** (external) leakage currents and the patient leakage currents. These include **LEAD TO GROUND** (source), **LEAD TO LEAD**

(auxiliary) and **ISOLATION** (sink) current. An **EXTERNAL** position is provided to measure leakage current between two points or isolation current of probes and transducers independent of their instruments.

8. **LEAD SWITCH** directs the selected patient lead measurement to the desired lead. When testing a 10 lead device, a second pass will be required for the C leads.

9. **METER** is a large, ½ inch, high contrast LCD 3½ digit display of the measured parameter. This will read up to 1999 with decimal points added where required.

10. **PATIENT LEAD SNAPS** provide means for connection of the patient leads for leakage current measurement.

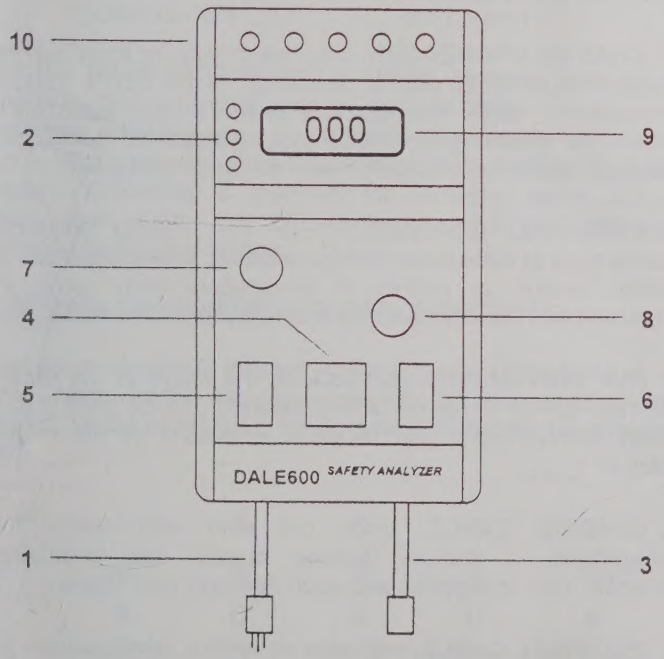


FIGURE 1: Front panel controls and indicators

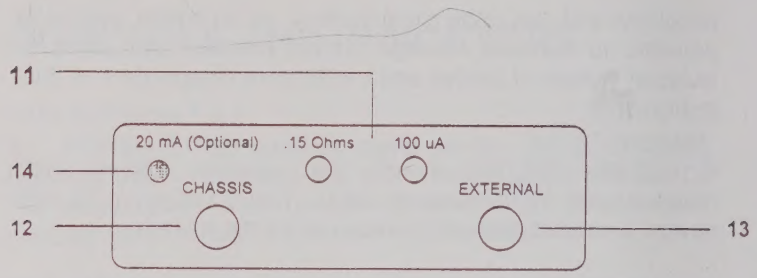


FIGURE 2: Rear panel controls and connectors

11. **TEST POINTS** of **0.15 Ω** and **100 µA** are provided to check the **DALE** *600/600E* Analyzers by clipping onto with the **CHASSIS** cable and selecting appropriately, **RESISTANCE** or **CHASSIS** leakage via the **FUNCTION** switch.

12. **CHASSIS CONNECTOR** provides means for inputting the **CHASSIS CABLE** with its clip for connection to the DUT's chassis or enclosure. With the **FUNCTION** switch in the **RESISTANCE** position, the chassis ground resistance is measured and in the **CHASSIS** position, the chassis leakage current is measured.

13. **EXTERNAL CONNECTOR** is for making external measurement of resistance, voltage gradient, leakage current or isolation current of probes or transducers when used in conjunction with the **CHASSIS CABLE** for the other reference point.

14 **mA SWITCH** (OPTIONAL) extends the range of the meter from 1999 µA to 19.99 mA when pressed. To be used if the leakage current goes over range as indicated by the meter display of 1_ _ _.

15. **CHASSIS CABLE,** black coil cord with clamp for measurement of chassis leakage current and grounding resistance. One is supplied with each Analyzer (not shown).

16 **EXTERNAL CABLE,** red cable of various configurations is an optional accessory for measurement of external leakage and isolation current in conjunction with the chassis cable (not shown).

PREPARING FOR USE

WARNING

TO ASSURE TOTAL SAFETY TO THE PATIENT, DISCONNECT ALL PATIENT CONNECTIONS TO THE DEVICE TO BE TESTED BEFORE STARTING.

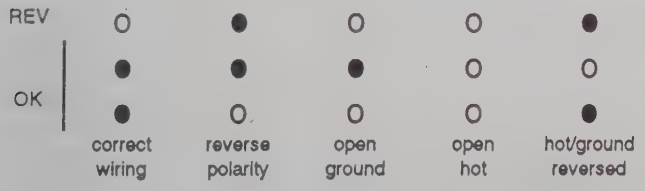
As it is best to start from the same position each time, place the analyzer's switches in the following initial positions:

FUNCTION switch	LINE VOLTS
LEAD switch	RL
NEUTRAL switch	CLOSED
POLARITY switch	OFF [center]

Plug the **DALE** ***600/600E*** into an outlet properly rated. The analyzers are equipped with a hospital-grade power plug. Grounding reliability can only be achieved when the analyzer is connected to an equivalent power receptacle marked "Hospital Grade". Grounding is important for personnel safety and to make some of the test offered by the analyzer. **Do not circumvent for any reason.**

VERIFYING THE POWER OUTLET CONNECTIONS

Note: not applicable to isolated power systems or the ***600E.***
Three neon lamps provide indication of the polarity and condition of the outlet being used as determined by the following chart.



Note: Does not check open neutral or neutral/ground reversal

If the line checks OK, plug the device to be tested into the analyzer's line receptacle. If the line is found faulty, correct the problem before proceeding.

MEASURING THE LINE VOLTAGE

From the recommended start position, FUNCTION switch in the LINE VOLTS position, the meter will display the line voltage with a resolution of one volt. Switching the POLARITY switch to the NORMAL position and turning on the DUT, the meter display will continue to read line voltage but under the load of the device being tested. Depending on the device's operating current and the electrical supply wiring, the voltage differential may be significant. The value under load should be checked against the device's ratings to be sure that the actual value remains within prescribed limits. Excessive drop also suggest that a dedicated line of increased capacity should be run to the instrument.

MEASURING THE DEVICE'S CURRENT

Switch the FUNCTION switch to CURRENT. The meter will display the device's current to 19.99 Amperes. The POLARITY switch should be in NORMAL, NEUTRAL CLOSED and the device turned on and placed in it's maximum load condition to obtain the proper reading. Logging this data may help in spotting problems early by noting changes in values.

MEASURING THE CHASSIS GROUNDING RESISTANCE

This test is only applicable to device's utilizing three wire (grounded) power cords. Connect the black coil cord cable to the CHASSIS connector on the rear panel of the analyzer. Clamp the clip of the cable to the DUT's exposed chassis or the enclosure if conductive. Care should be taken to assure that bare metal is reached and that both jaws of the clip are in contact with the chassis. Metal labels or incidental conductive hardware should not be used for this test.

If a non-conducting enclosure is used, and no chassis is readily accessible, a safety ground terminal can be used. If no conductive ground is accessible, then the only recourse is to open the device to reach a conductive chassis or put on hold pending service requirement to the device.

Once connection is made, rotate the FUNCTION switch to RESISTANCE and read its value directly in ohms to 19.99 ohms. This test is best made with the POLARITY switch in the OFF (center) position.

MEASUREMENT OF LEAKAGE CURRENTS

EARTH CURRENT

The earth leakage current is that current that flows normally in the ground wire of the device and thus only applicable to devices utilizing three wire (grounded) power cords. See section on "What is Being Measured" for additional discussion on earth leakage current.

The current is measured by switching the FUNCTION switch to EARTH. The leakage current will be displayed to 1999 µA (microamperes). Measurement should be made under all combinations of the POLARITY switch, NORMAL and REVERSE, NEUTRAL switch, CLOSED and OPEN and the device power turned ON and OFF. **BE SURE TO PAUSE IN THE OFF (MIDDLE) POSITION WHEN SWITCHING FROM NORMAL TO REVERSE.**

If equipped with the **mA** option and the meter indicates an over range (1_ _ _), press the **mA** switch on the rear panel to change the range to 0-19.99 mA. This is a momentary actuated switch and will return to the normal 0-1999 µA range when released.

CHASSIS [ENCLOSURE] CURRENT

The chassis [enclosure] leakage current is that current that flows between the conductive chassis or enclosure and earth (ground) measured through a 1,000 ohm impedance.

Connect the black coil cord cable to the CHASSIS connector on the rear of the Analyzer. Clamp the clip on the cable in turn to accessible conductive sections of the chassis and the enclosure. Metal labels or incidental conductive hardware are not applicable for this test.

If a non-conducting enclosure is used, present standards require connection to the enclosure via a 200 cm^2 conductive foil in intimate contact with the enclosure. This can be accomplished

with a 14 x14 cm, (5.5 x5.5 in) piece of aluminum foil taped to the surface and the cable clipped to the foil.

To make the measurement, place the FUNCTION switch in the CHASSIS position and read the display in microamperes. If over range, press the **mA** switch (OPTIONAL) on the rear panel to change the range to 19.99 mA. Readings should be made under all combinations of the POLARITY switch, NORMAL and REVERSE, NEUTRAL switch, CLOSED and OPEN, TEST switch to LIFT GND and device's power ON and OFF.

LEAD TO GROUND [PATIENT SOURCE] CURRENT

Patient lead to ground leakage current is that current that would flow through individual patient leads and all patient leads connected together if the patient was to come into contact with earth ground.

Connect the patient leads to the corresponding snaps on the top of the Analyzer. If the device has 10 leads, connect the limb leads and C1 initially and repeat with C2 through C6. Lead nomenclature for this test is not important.

Select LEAD TO GROUND with the FUNCTION switch and read leakage current in microamperes for any combination of the POLARITY switch, NORMAL and REVERSED, NEUTRAL switch, CLOSED and OPEN, the ground intact and LIFTED and DUT power ON and OFF for the patient lead selected by the LEAD switch. Rotate the LEAD switch to each lead to test individually and then to ALL for testing with all leads connected together.

LEAD TO LEAD [AUXILIARY] CURRENT

The lead to lead current is the current that flows from any patient lead to any other patient lead and to all other leads connected together. Under normal conditions the current is primarily input bias current, measurement current or lead off sensing current. The worst case condition will be measured from the individual lead to all others connected together. This is the measurement made by the DALE *600/600E* Electrical Safety Analyzers.

Measurement is made with the patient leads connected to the snaps on top of the analyzer and the FUNCTION switch placed in the LEAD TO LEAD position. Selection by the LEAD switch will test the individual leads. Note the ALL position has no meaning in this test.

If the device under test utilizes a 10 lead patient input, test each C lead in turn individually. For test of the RL reference lead, utilize the C lead adapter to properly sum all the lead currents flowing to the reference.

LEAD ISOLATION [PATIENT SINK] CURRENT

WARNING

HIGH VOLTAGE, 120/220 VOLTS WITH RESPECT TO EARTH GROUND IS ACCESSIBLE AT THE PATIENT CONNECTIONS (SNAPS) DURING PART OF THIS TEST. TAKE CARE WHEN HANDLING THE PATIENT LEADS.

The patient lead isolation current is that current that would flow in individual leads or all leads connected together if line volts, 120/220 volts with respect to earth ground were to come into contact with the patient.

Measurement is made with the patient leads attached to the snaps on top of the analyzer, the FUNCTION switch placed in LEAD ISOLATION position and the individual lead to be tested selected by the LEAD switch. To apply the high voltage to the lead safely, press the TEST lever to ISO TEST The voltage is only applied when pressed. While ISO TEST is energized, read isolation current in microamperes. Test should be performed in all combinations of the POLARITY switch, NEUTRAL switch and with the device under test ON and OFF.

EXTERNAL MEASUREMENTS

DALE *600 and 600E* provides the capability of making **leakage current** and **isolation current measurements** between selected points. For leakage current measurements, connect the black coil cord cable to the CHASSIS connector and the red cable to the EXTERNAL connector on the back of the Analyzer. With the FUNCTION switch in the EXTERNAL position, clip the two

cables to the two points for which the leakage current is to be measured. The meter will display the leakage current between the two points to 1999 μA. The number displayed is also the voltage gradient in millivolts between the two points based on a volt meter with an input impedance of 1000 Ω. Note if provided with the **mA** option, the range can be extended to 19.99 mA or 19.99 volts by pressing the **mA** switch on the rear panel as previously described.

To measure the electrical isolation of a probe or transducer, electrical connection must be made to each sides of the isolation barrier by a red and black cable as described above. Set the function switch to external and press the TEST switch to ISO. This will apply isolated line voltage between the two sides and the meter will display the isolation current that flows. Actual method for making connection to either side of the isolation barrier will vary with the device to be tested and thus full details cannot be provided here. Dale has developed some adapters for specific applications, see Accessories and will be happy to work with you on your special needs.

In addition, the **DALE** *600/600E* can make **resistance measurements** between selected points. If electrical devices are involved, it is desirable that they be turned off. Connect two black chassis cables to the CHASSIS and EXTERNAL connectors and clip onto the two points to be measured. Set the FUNCTION switch to RESISTANCE and the display will read the resistance between the two points. To compensate for possible DC components in the leakage current flowing between the two points, reverse the two clips and average the readings. Note, it is necessary to remove any device connected to the device receptacle in the analyzer to make this measurement.

WHAT IS BEING MEASURED

This section reviews the parameters being measured by the DALE *600/600E* Digital Safety Analyzers, how they occur and typical values to be found.

Figure 3 is a rough block schematic of a typical line operated instrument with patient connections. All measured parameters are labeled for discussion. Understanding the mechanism that creates these parameters should be helpful in investigating and resolving problems that may arise and thus ensuring a safer environment. It should be recognized that these voltages and currents are a natural phenomena and their presence within reasonable limits do not constitute a hazard. A significant change from previous measurement or from the device specification should be carefully reviewed with suspicion.

LINE VOLTAGE [V_L] is the mains power supplied by the electrical distribution system of the hospital. It is shown as a three wire system of HOT, NEUTRAL and GROUND with NEUTRAL like GROUND returned to true earth at their entry into the building. The voltage measured will depend upon :

- the power utility company's output and distribution to the hospital
- the distribution system within the hospital, primarily a function of age where older systems have marginal capacity for the electrical needs of todays equipment
- the load on the line being measured, not only that of the device under test, but of other devices on the same line

The DALE *600/600E* measurement is made between the HOT and NEUTRAL wires via transformer coupling to isolate the measuring circuits from the line. As recommended, measurement of the line voltage with the device under test OFF and then ON will provide indication if the line is adequate for the device. A large drop may suggest that a dedicated line of higher ampacity should be run in for the device.

INSTRUMENT CURRENT [I_L] is the current used by the device under test. When turned on, the device should be operated in its various modes to determine the worst condition to track. Verify that the device under test current is within the current rating of the **DALE *600/600E*** being used. This should be evident when trying to connect a device of higher rating as the connector pair should not match.

Measurement is made in the HOT wire via transformer coupling to ensure that the total current is measured as it is possible that the NEUTRAL and GROUND wire could share the return path.

CHASSIS RESISTANCE [R_G] (grounding resistance) is the resistance from the device's conductive "grounded" chassis to the grounding terminal on the receptacle in which it is plugged. The resistance is largely made up of the GROUND wire in the power cable and directly proportional to its length. See Table 1 for typical values for a 10 foot cable. The resistance measurement also includes the junction resistance in connecting the wire at both ends and the bulk resistance of the chassis from the grounding point to the point of measurement.

Table 1

GROUND RESISTANCE OF 10 FT. POWER CABLE

(Will vary slightly with wire stranding)

WIRE SIZE AWG	RESISTANCE MILLIOHMS
18	64
16	41
14	25

Underwriters Laboratory (UL) limits the ground resistance to 100 milliohms (0.1 ohms) for new products and National Fire Protection Association (NFPA) to 150 milliohms, 500 milliohms for devices in the field. Maintaining a low resistance is important to protect against the chassis becoming "hot" as a result of an internal fault causing current to flow to the chassis. The resulting voltage drop across the ground wire will raise the potential of the chassis with respect to the local ground and thus create a potential hazard.

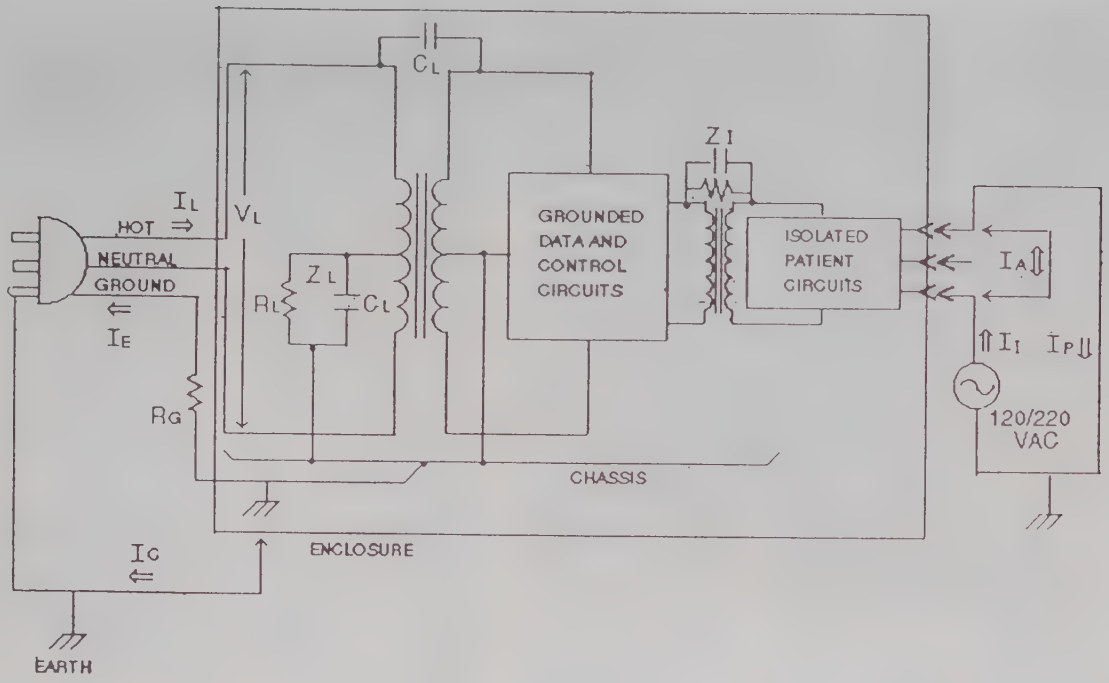


FIGURE 3: Block schematic of a line operated instrument with isolated patient circuits to evaluate measurements made with the **DALE** *600/600E*.

Because of the low values of resistance being measured, the **DALE *600/600E*** utilizes a four wire Kelvin bridge to make the measurement. This avoids the introduction of errors due to contact resistance of the cable connectors as well as the length of the test cable. Resistance is measured between the clip on the black chassis cable and the grounding pin receptacle of the **DALE *600/600E.***

EARTH CURRENT [I_E] (internal chassis current) is that current that flows in the GROUND wire of the power cable to return the chassis leakage current to true earth ground. This current does not constitute a hazard as long as the ground wire remains intact and the current does not become excessive. This could occur by a major fault, resulting in the ground wire sharing the load current with the neutral wire or supplying the total return. Under these conditions in addition to the rise of the chassis potential with respect to the local ground reference, the local ground reference can rise with respect to true earth as established by the cold water pipes. This is as the result of the ground wire resistance back to the building entrance. It should be pointed out that this current becomes the chassis leakage current for conductive enclosure when tested under open ground condition as discussed below.

Leakage current is due to the proximity of the hot wire or line potential components to the chassis represented by Z_L, a combination of capacitance, C_L, and resistance, R_L, components. Particular sources of this current:

- Power transformers and motors which have large winding masses in close proximity to large conductive masses which are physically mounted to the chassis. Such leakage can be both capacitive, across a dielectric and resistive through conductive flux residue or poor insulation.
- Line filters installed to protect against conductive EMI, particular in newer computerized devices. These components include real capacitance from both the HOT and NEUTRAL wires to ground. Typical leakage current are in the 100 to 500 µA range although special low leakage units, down to 50 µA are available specifically targeted for the medical device industry.

- Switching power supplies with significant electronics directly connected to the power line and complicated by the introduction of the higher switching frequencies used in the supply.
- Power cable with the parallel run of the HOT wire in intimate contact with the GROUND wire. Leakage current is dependent upon wire gage, insulation dielectric and length. Typical values for a ten foot cable can range from 10 to 15 μA. Special low leakage cable is available from Dale Technology with comparative leakage of 3 to 4 μA.

Measurement is made using the 1000 ohm AAMI load placed directly in series with the ground wire. Open neutral will usually represent the worst case.

CHASSIS [ENCLOSURE] LEAKAGE CURRENT [Ic] also referred to as external leakage current is that current that flows between the accessible conductive chassis or enclosure and earth ground. As stated above, this current under the condition of an open ground is the same as the earth current. With ground intact, the current should be very low reflecting the milliohm impedance of the ground wire paralleling the 1000 ohm AAMI load.

Differentiation the earth and chassis currents is made due to the wide use of insulated enclosures today and thus no accessibility to a conductive chassis. Under these conditions the earth current represents total leakage current while the chassis current measured with a 14x14 cm piece of foil placed in intimate contact with the enclosure provides indication of potential hazard due to contact. Capacity between the chassis and the foil will determine the current measured which usually will be low.

The **DALE** ***600/600E*** makes this measurement as the current flowing in the black chassis cable clipped to the chassis back to the ground for the system with the 1000 ohm AAMI load. Measurement should be made under all conditions, particularly with ground lifted and open neutral which usually represents the worst case.

LEAD TO GROUND [I_P] (patient source) current is that current that flows between an individual patient lead and ground. It represents the condition of a patient with leads attached touching ground such as an electric bed. If the patient connections are not isolated, then this current will reflect the earth current when tested under the open ground condition as this is its only path back to true earth.

For devices incorporating isolated patient connections, this current is reduced by the patient isolating impedance Z_I, a combination of resistive and capacitive leakage. Although originally required only for devices incorporating intra-cardiac electrodes or conductive pathways directly to the heart, it has found its way into standards for all devices having any patient applied parts.

Measurement is made to the lead selected by the lead selector switch with the other side of the AAMI load connected to system ground. Current measured should be the same for all leads including the **ALL** position as the current represents the isolation impedance to the patient circuit.

LEAD TO LEAD [I_A] (auxiliary current) is that current that flows from one lead to another lead and includes the following:

- Bias current of the input amplifier
- Reverse leakage current of input protection diodes,
- Lead-off sensing current
- Impedance measurement current such as for respiration

The currents can be DC or AC or a combination and thus needs to be measured utilizing true RMS technique. This avoids the wave form introducing errors in converting to an RMS value since each wave form has their own conversion factor. The DALE *600/600E* measurements are made with a true RMS converter to provide the common base necessary for accurate readout with a variety of common wave forms.

Measurement is made with a completely floating circuit to avoid extraneous leakage currents to ground introducing errors. Measurement is made from the selected lead to all other leads connected together as this represents the worst case and to reduce the permutations required to cover all possibilities. The

single lead carrying the most current will in general be the reference lead, R_L as this acts as the return for the other leads. For this reason, to obtain a true reading of the reference lead in a 10 lead system, a C lead adapter, Dale P/N 600/500 is required to extend the chest lead capability. Alternatively, the leads can be taken in groups of 4 with the common reference lead, R_L, and summed.

LEAD ISOLATION [I_I] (patient sink) current is that current that would flow into the device under test if the patient were to come into contact with full line voltage. This could occur again with an electric bed but which has become ungrounded and has a short to the frame. While measurement is made in each individual leads, a common value will be found for all leads as well as for the ALL position as this is the measurement for the isolation of the patient circuit. To assure proper reading, test should be run with ground intact.

For this test, the **DALE** ***600/600E*** provides a specially shielded line voltage secondary on its power transformer that minimizes internal leakage currents from the measuring circuit and thus avoids the necessity of measuring that current and subtracting it from all readings. The current is limited to approximately 1 mA for user protection and for additional safety, only applied to the patient leads when the TEST switch is pressed to ISO.

EXTERNAL MEASUREMENT capability is provided to extend the use of the **DALE** ***600/600E*** to that of a:

- ohmmeter capable of making resistance measurements in the milliohm range for chassis bonding measurements.
- low impedance (1,000 Ω) voltmeter as specified by the NFPA, with a range to 1,999 mV or with the mV option, 19.99 volts when the **mA** switch is pressed.
- 1,000 Ω microammeter to measure the leakage current between two devices or between the DUT and a local ground reference. Range is to 1,999 µA or 19.99 mA with the mV option and the **mA** switch pressed.
- isolation tester for ultrasound probes and other transducers independently from the device in which it is used.

RESISTANCE MEASUREMENTS between two points is made to verify the integrity of permanently installed equipment whose ground cannot be broken to measure the chassis leakage current. These devices are usually high power devices which can have high leakage currents and depend on the bonding of all chassis to a common point for safety.

The resistance between two points is measured in the RESISTANCE mode of the FUNCTION switch and utilizing two black chassis cables for input leads through the CHASSIS and EXTERNAL connectors. Care needs to be exercised to insure that ground connections do not provide parallel measurement circuits resulting in erroneous results. This is accomplished by not connecting any device to the DALE *600/600E* instrument receptacle.

Measurement is made with 10 mA DC current and is highly resistance to AC currents flowing between the measurement points as a result of chassis leakage current from either or both devices. However, such leakage current may have a DC component from rectification within the instrument. This DC current adds and subtracts from the measurement current resulting in some error. This can be corrected for by reversing the connections and averaging the two readings.

LEAKAGE CURRENT AND VOLTAGE GRADIENT between two points is also measured for permanently installed as additional verification of the integrity of the installation. These measurements are equivalent as the relationship between volts and current across 1,000 Ω is one mV per μA.

Measurement is made from the EXTERNAL position of the FUNCTION switch with one black cable in the CHASSIS connector and a red cable in the EXTERNAL connector as meter inputs. The measurement circuit is isolated from ground and to be maintained, must avoid having a device plugged into the Analyzer's receptacle. These should be removed during any external measurements.

Connection of the two cables to the surface of choice will result in direct display of the leakage current or gradient. The range can be expanded to 19.99 mA and 19.99 volts by the mA OPTION and operation of the **mA** button if the display over-ranges.

ISOLATION TESTING of probes and transducers making internal contact to a patient is provided to assure the reliability of the isolation barrier. These devices incorporate electrical circuits which can introduce or sink hazardous currents to the patient if he comes into contact with line potential or becomes grounded as previously described. Additional difficulty is generated with these devices as they generally require sterilization before use. Thus testing before sterilization is recommended.

While electrical contact to the internal circuits are made via a multi contact connector, the patient side is usually through fluid coupling. The probe connector connection to the Analyzer is made via a special adapter. Dale has developed some adapters and will work with you to meet your requirements. Contact with the patient side of the isolation barrier can be made via saline with electrical contact to the saline made through the chassis ground probe, P/N 600/102 or other grounding means as required for the device.

These cables and adapters are connected to the Analyzer through the **CHASSIS** and **EXTERNAL** connectors with the black cable connected to the **CHASSIS** input and the red cable to the **EXTERNAL** input. The **FUNCTION** switch is set at **EXTERNAL** and the test switch pressed to **ISO**. This applies 120 V or 220 V between the leads of the probe or transducer and the patient applied part and the leakage current displayed on the meter. As above, the measurement is isolated from ground to eliminate errors from extraneous currents.

MAINTENANCE AND CALIBRATION

Your **DALE** ***600/600E*** needs little maintenance or special care. However it is a calibrated measuring instrument and should be treated as such. Avoid dropping or other mechanical abuse that could cause a shift in the calibrated settings.

CLEANING the analyzer should be done occasionally utilizing a damp cloth and a mild detergent. Care should be taken to avoid the entrance of liquids.

CABLES should similarly be wiped down with the same care and inspected for damage and deterioration of the insulation. The cable entrance to their connectors should be checked for integrity of the cable clamp and strain relief.

VERIFICATION of general performance can be observed by utilizing the two test points located in the back of the instrument. Both the leakage current and resistance measurement circuits are checked for performance.

VOLTAGE (line) can be verified with a multi meter although the reading itself is self evident.

CURRENT is verified by connecting a lamp with a standard incandescent bulb to the DUT receptacle and switching the POLARITY switch to NORMAL. Display should read approximately as follows:

BULB WATTS	CURRENT AMPS	
	120V LINE	220V LINE
60	0.50	0.30
75	0.63	0.35
100	0.83	0.45
150	1.25	0.70

RESISTANCE is checked by connecting the black chassis cable to the **CHASSIS** connector and clipping to the **.15 Ω** test point. Display should read 0.15 ±.02.

EARTH is checked by connecting the black chassis cable to the **EXTERNAL** connector and clipping to the **100 µA** test point. Display should read 100 ± 2.

CHASSIS leakage current is checked by connecting the black chassis cable to the **CHASSIS** connector and clipping to the **100 µA** test point. Display should read 100 ± 2.

LEAD TO GROUND function is checked by clipping a clip lead to the **100 µA** test point and the other end to the **LEAD** snap selected. Display should read 100 ± 2.

LEAD TO LEAD is checked in the same manner as **LEAD TO GROUND** above.

LEAD ISOLATION current is checked by connecting the black chassis cable to the **EXTERNAL** connector and the clip to the lead selected. Press **TEST** switch to **ISO**, display should read 1000 ±15% depending on line voltage.

EXTERNAL operation can be checked for leakage current measurement by connecting the red external cable to the **EXTERNAL** connector and clipping to the **100 µA** test point. Display should read 100 ± 2.

To check for isolation measurement, clip the red external cable to the black chassis cable and press the **TEST** switch to **ISO**. Display should read approximately 1000 ±15% depending on the line voltage.

CALIBRATION of the DALE *600/600E* is best done at the factory on a yearly schedule as we are equipped with the appropriate tools and reference instruments traceable to the National Institute of Standards and Technology, (NIST). A built in calibration sticker is provided on the back to help insure that the schedule is followed. In addition Dale Technology will send the buyer a postcard when recalibration is due.

When returning the analyzer, first call your Customer Service Representative at 1-800 544-3253 for a return authorization number and instructions. Units should be sent to:

Customer Service
Dale Technology, Inc.
401 Claremont Avenue
Thornwood, NY 10594

ACCESSORIES

DESCRIPTION	PART NUMBER
CHASSIS CABLE: For measurement of chassis resistance and chassis leakage current. Also used as reference lead for external measurement. Black coiled cord 8 feet extended with chassis clip.	600/100
CHASSIS CABLE: Same as above except 16 feet extended.	600/101
CHASSIS GROUND PROBE: For measurement of chassis resistance and chassis leakage current. Also used for For grounding saline baths for isolation testing of probes and transducers. Black coiled cord with stainless steel needle probe for testing receptacles and for tight spaces, 8 feet extended.	600/102
CHASSIS GROUND PROBE: Same as above except 16 feet extended	600/103
EXTERNAL LEAKAGE CABLE: Standard auxiliary cable for external measurements of leakage current and voltage gradient between two conductive surfaces. Coiled cord 8 feet extended with red chassis clip.	600/200
EXTERNAL LEAKAGE CABLE: Same as above except 16 feet long.	600/201

DESCRIPTION	PART NUMBER
PROBE ADAPTOR CABLES: For making electrical contact with all terminals of internal ultrasound probes for isolation testing. Red cable with connector adapter, 6 feet long.	
GEYMS probe	600/202
GE RADIUS/SONO probe	600/203
LOGIQ series probe	600/204
C LEAD ADAPTER: Adapter to extend patient lead capability to 10 lead ECG for leakage current measurement.	600/500
14 LEAD SWITCH BOX: Adapter to extend lead selecting capability to fully test a 14 lead electrocardiograph	600/501
SOFT CARRYING CASE: Case to protect the **DALE** *600*/600*E* when placed in a tool box and to carry it's accessories	600/600
HARD CARRYING CASE: Case for carrying the **DALE** 600/*600E* and it's accessories.	600/700
INSTRUCTION MANUAL: Instruction manual for the **DALE** *600/600E* ELECTRICAL SAFETY ANALYZERS.	600/900

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